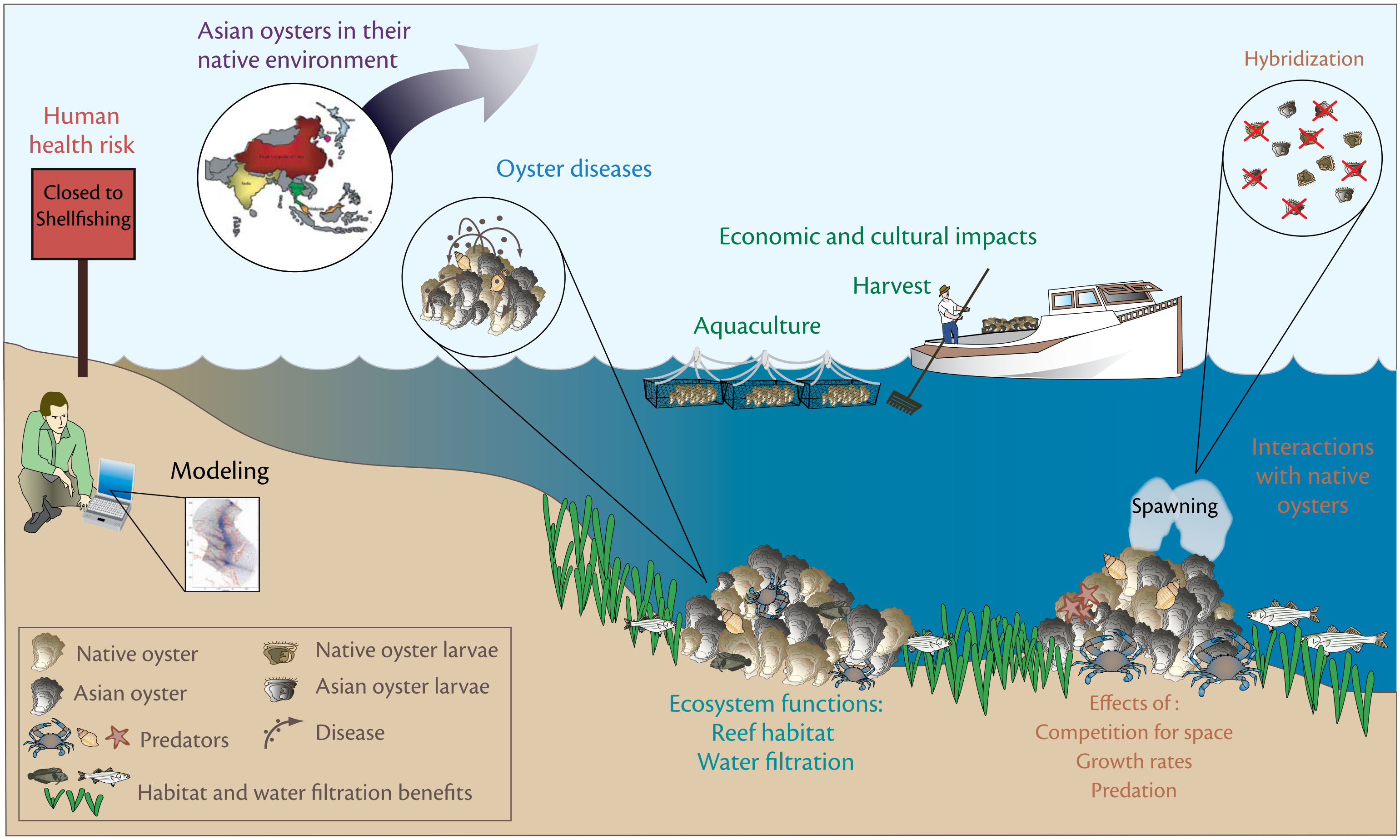
ASIAN OYSTERS:
SCIENCE TO INFORM POLICY DECISIONS

The dramatic decline of Chesapeake Bay's native oyster — the Eastern oyster, *Crassostrea virginica* — has led to the collapse of a formerly productive fishery and loss of important ecological functions such as reef habitat formation and water filtration. Historic overharvesting, habitat loss, poor water quality, and two oyster diseases, MSX and Dermo, have contributed to the decline and continue to hinder oyster restoration efforts. One potential solution being considered by the State of Maryland and Commonwealth of Virginia is to introduce an oyster species from Asia – the "Suminoe" oyster, *Crassostrea ariakensis**. This particular species was selected because initial tests showed fast growth and greater resistance to MSX and Dermo. Concerns about the possible risks associated with a non-native introduction have resulted in a cautious approach, which includes several years of focused research to answer key questions about the Asian oyster.

Therefore, federal and state agencies are preparing an Environmental Impact Statement (EIS) to examine the risks and benefits of introducing the Asian oyster, as well as seven alternative actions that individually or in combination could increase oyster stocks to achieve the desired economic and ecological benefits. A draft EIS is expected to be released for public review in 2008. Since 2004, the National Oceanic and Atmospheric Administration (NOAA) has supported a research program to provide scientific information for the EIS. State agencies have also provided funding for many projects. The research agenda has been guided by recommendations and priorities identified by local, national, and international science advisory groups[1-3].

This overview presents the major research topics under investigation (see figure below). The research includes more than 50 studies conducted by scientists at 15 academic institutions, government research laboratories, and environmental consulting firms. More information on this research and the Environmental Impact Statement can be found at the websites listed on the back page.



Research to support the EIS covers a broad range of topics, including: performance of Asian oysters in their native environment; whether Asian oysters could provide key ecosystem functions; the likely outcome of interactions with native oysters; whether the Asian oyster might influence the dynamics of established or new oyster diseases; human health risks associated with consumption of Asian oysters compared with native oysters; and economic and cultural impacts. Research results and modeling predictions will be used to evaluate the proposed introduction and alternatives in the EIS.

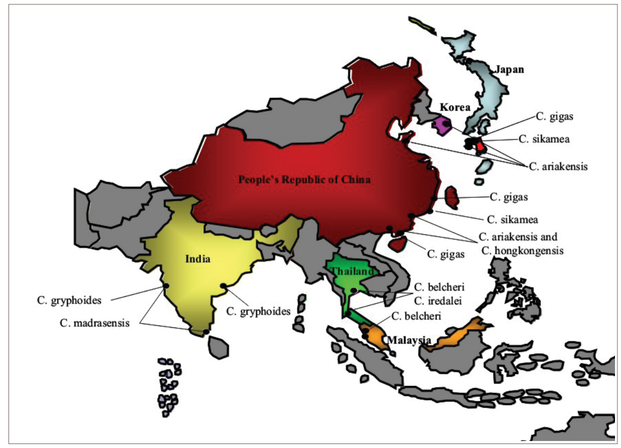
* *referred to as the Asian oyster throughout this newsletter*

ASIAN OYSTERS IN THEIR NATIVE ENVIRONMENT

Knowing where the Asian oyster naturally occurs and how it coexists with other species can help us predict how it might perform and interact within Chesapeake Bay and other Atlantic coast ecosystems. At least seven different oyster species in Asia have been commonly misidentified as *C. ariakensis*. Scientists are working to resolve this confusion in order to determine the actual distribution and ecology of this species in its native environment.

The specific strain of *C. ariakensis* proposed for introduction derives from a dozen or so individuals that were propagated following their unintended arrival at an Oregon oyster hatchery via a shipment of other live oysters from Japan in the early 1970s. Due to the small number of individuals used to establish the "Oregon strain", reduced genetic diversity is a concern.

Researchers are studying the genetics of *C. ariakensis* populations in Asia and comparing genetic diversity between wild populations and captive hatchery strains. This information will help clarify whether the Oregon strain is the one best suited for introduction, and how significant the genetic bottleneck issue may be in successfully establishing new populations of this oyster in the Chesapeake region.



Jan Cordes (VIMS)

ECOSYSTEM FUNCTIONS

Ximing Guo (Rutgers)

The native oyster is a prolific builder of reefs that provide important habitat for many other species. Not all oyster species are reef-builders — some are referred to as "rock oysters" because their flat growth form hugs the surface of rocks and other substrates. Through experiments in the United States and observations of wild populations in Asia, scientists are exploring whether the Asian oyster could fill this important ecological role in the Chesapeake region.

Another critical ecosystem function that oysters perform is water filtration, which removes excess phytoplankton and sediment and improves water clarity. All oysters are filter feeders, but species vary in filtration rates and the sizes and types of particles they remove from the water. Researchers are gathering data on how Asian oysters filter feed, and are using the data in models to estimate the water quality improvements that can be expected from native and Asian oysters at various population sizes.

Might a successful introduction of the Asian oyster provide too much of a good thing? Fouling of docks, boats, buoys, and water intake structures can have significant economic costs, as in the case of non-native zebra mussels in the Great Lakes. Research on Asian oyster biology and ecology will provide insight on the potential for this species to become a fouling nuisance if it is introduced.

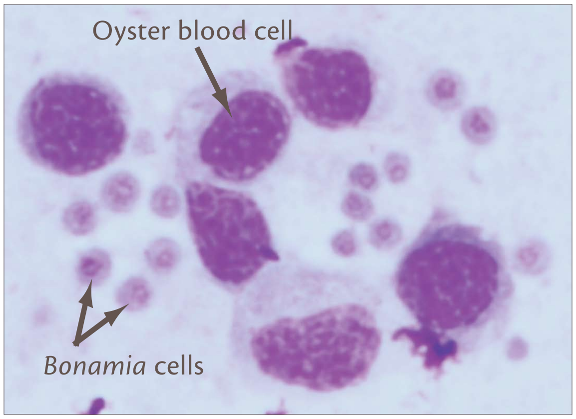
INTERACTIONS WITH NATIVE OYSTERS

If larvae of native and Asian oysters prefer similar substrates for settlement, it is likely they would eventually co-occur and compete for the severely limited amount of hard bottom habitat presently available in Chesapeake Bay. Generally faster growth and lower disease mortality may give the Asian oyster a competitive advantage over the native oyster in the long term. On the other hand, the Asian oyster's weaker shell may make it more vulnerable to some common oyster predators like crabs. Field and laboratory studies are providing information that we can piece together for insight on whether one species might out-compete and eventually eliminate the other over time.

Al Curry (VIMS)

During reproduction, native and Asian oysters can cross-fertilize, but the hybrid larvae die after several days. Production of inviable hybrids creates a "gamete sink" — the loss of gametes that could otherwise produce healthy, single-species offspring. Scientists are determining the likelihood that native and Asian oysters would co-occur and spawn at the same time, and examining how hybridization could negatively affect the reproductive success of both species.

OYSTER DISEASES



Ryan Carnegie (VIMS)

Although Asian oysters seem to suffer less mortality than native oysters from Dermo and MSX, we also need to understand whether their introduction might worsen the impact of these diseases on native oysters. Scientists are conducting experiments to learn whether Asian oysters can serve as a disease reservoir or transmission vector (source or sink) for a range of oyster pathogens.

Bonamia, an oyster pathogen not previously known to occur in the mid-Atlantic region, recently caused mass mortalities of young Asian oysters in controlled field trials conducted in North Carolina. Although *Bonamia* infections have not been documented in Chesapeake Bay and the pathogen does not appear to affect native oysters, it is possible that *Bonamia* could spread to the Chesapeake if a suitable host were present. Researchers are studying the geographic distribution and environmental tolerances of *Bonamia* in North Carolina in order to understand how the Asian oyster may be limited by this disease at salinities and temperatures characteristic of Chesapeake Bay and other Atlantic coast waters.

HUMAN HEALTH RISK

Judy Kleindinst (WHOI)

As filter feeders, oysters can concentrate toxins and pathogens such as bacteria, protozoans, and viruses within their tissues at levels much higher than those of the surrounding water. Human illness from the consumption of raw oysters is a risk that is proactively managed by food safety practices including water monitoring, closure of contaminated shellfish harvest areas, and post-harvest handling standards. These regulations and standards have been developed from research and experience with shellfish species already present in the United States.

Economic revitalization of the oyster fishery is one of the reasons for the proposed introduction of the Asian oyster. In controlled taste tests consumers rated the taste, appearance, aroma, and texture of Asian oysters as favorable, and many participants indicated they would buy Asian oysters if available at a competitive price.

Thus, a key question is whether existing water quality and product handling standards will be sufficiently protective of human health in the case of this new species. Will the Asian oyster pose a greater, lesser, or similar risk for human health compared with the native oyster? Scientists are answering this question by comparing the rates of accumulation, depuration (clearance from tissues), and post-harvest decay of human pathogens in native and Asian oysters.

ECONOMIC AND CULTURAL IMPACTS

Don Webster (UMD)

Oysters were once the most economically important fishery of Chesapeake Bay, and today remain a cultural icon reflecting the unique flavor and maritime heritage of the Chesapeake region. Income from fall and winter oystering is critically important for communities struggling to maintain the traditional waterman's way of life. In addition to harvest, the ecological functions that oysters perform also have economic value (e.g., recreational fishing, nutrient removal, habitat creation).

The EIS will evaluate economic and cultural impacts of the proposed introduction and alternatives such as expansion of native oyster restoration efforts, a harvest moratorium, and aquaculture of native oysters or triploid (reproductively sterile) Asian oysters. Economists and cultural anthropologists are studying factors including: native oyster restoration costs compared with Asian oyster introduction; effectiveness of past fishery management practices; influence of market forces on the fishery; economic feasibility and potential of oyster aquaculture; dollar value of nutrient removal by oysters; societal values associated with oysters; and cultural changes that might result from various oyster management decisions. Oyster biologists and private industry are providing biological and economic information on various methods of oyster aquaculture, for example, caged versus on-bottom cultivation, use of diploid versus triploid oysters, and the potential for these practices to produce oysters with suitable characteristics and prices for the half-shell or shucking markets.

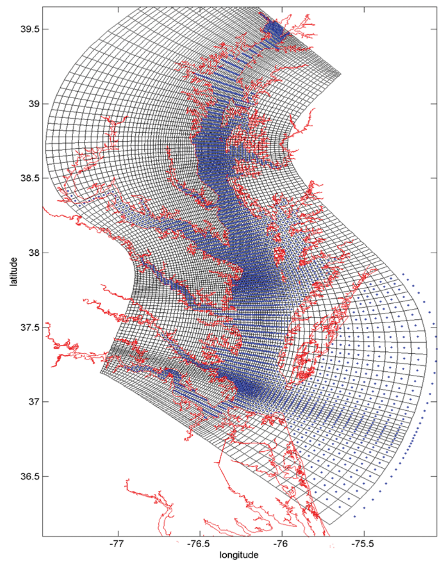
In total, this information will enable decision makers to better weigh the economic and cultural costs and benefits of introducing Asian oysters against other management options.

MODELING TO INTEGRATE DATA

We cannot safely test diploid (reproductively capable) Asian oysters in the field in advance of an actual introduction, but we can use models and the results of carefully controlled field and laboratory studies to predict likely outcomes of the proposed introduction and alternatives. An oyster population model and larval transport model have been developed to integrate information from the many field and laboratory studies yielding relevant data.

The larval transport model combines hydrodynamic simulations of Chesapeake Bay with data from larval behavior studies to provide insight on how native and Asian oyster larvae are likely to disperse. The demographic model tracks simulated oyster populations on more than 2,000 oyster bars in the Bay and incorporates output from the larval transport model to predict population growth, decline, and geographic distribution in subsequent generations.

Many risks associated with an Asian oyster introduction cannot be modeled, however, and must be considered as part of the broader assessment in the Environmental Impact Statement.



Ming Li/Liejun Zhong (UMCES)

For more information:
NOAA: Non-native Oyster Research *http://chesapeakebay.noaa.gov/nonnativeoysters.aspx*
Maryland Department of Natural Resources: In Focus – Oysters *http://www.dnr.state.md.us/dnrnews/infocus/oysters.asp*
Larval transport model for the EIS: *http://northweb.hpl.umces.edu/research/Oyster_larvae_DNR.htm*
NOAA Chesapeake Bay Oyster Larvae Tracker (CBOLT) *http://www.csc.noaa.gov/cbolt/*

References cited in the text:

[1] National Research Council (2004). Non-native Oysters in the Chesapeake Bay. The National Academies Press: Washington, DC. 325 pages.
[2] Scientific and Technical Advisory Committee (2004). Identifying and prioritizing research required to evaluate ecological risks and benefits of introducing diploid *Crassostrea ariakensis* to restore oysters to Chesapeake Bay. Report of the STAC Workshop December 2-3, 2003 Annapolis, Maryland. STAC Publication 04-002. Available online: *http://www.chesapeakebay.net/pubs/STACCariakensisReport.pdf*
[3] International Council for the Exploration of the Sea (2004). ICES Code of Practice on the Introductions and Transfers of Marine Organisms 2004. Available online: *http://www.ices.dk/reports/general/2004/ICESCOP2004.pdf*

Publications:

Alavi, MR et al. 2007. *Journal of Shellfish Research*, submitted.
Alexander, JA et al. *Journal of Shellfish Research*, in press.
Audemard, C et al. *Journal of Shellfish Research*, in press.
Bean, T et al. NOAA Technical Memorandum NOA NCCOS 25. 32 pp.
Bean, T et al. *Journal of Shellfish Research*, in press.
Bishop, MJ and PJ Hooper. 2005. *Aquaculture* 246:251-261.
Bishop, MJ and CH Peterson. 2006. *Ecological Applications* 16:718-730.
Bishop, MJ and CH Peterson. 2006. *Journal of Shellfish Research* 24:995-1006.
Bishop, MJ and CH Peterson. 2006. *Oecologia* 147:426-433.
Bishop, MJ et al. 2006. *Marine Ecology Progress Series* 325: 145-152.
Bushek, D et al. 2007. *Journal of Shellfish Research*, in press.
Burreson, EM et al. 2004. *Journal of Aquatic Animal Health* 16:1-9.
Carnegie, RB et al. 2006. *Journal of Eukaryotic Microbiology* 53: 232-245.
Grabowski, JH et al. 2003. *Journal of Shellfish Research* 22:21-30.
Grabowski, JH et al. 2004. *Journal of Shellfish Research* 23:781-793.
Grabowski, JH et al. 2007. *Journal of Shellfish Research* 26:529-542.
Graczyk, TK et al. 2006. *Applied and Environmental Microbiology*. 72: 3390–3395.
Moss, JA et al. 2006. *Journal of Shellfish Research* 25:65-72.
Moss, JA et al. *Diseases of Aquatic Organisms*, in press.
Moss, JA et al. *Journal of Eukaryotic Microbiology*, submitted.
Newell, RIE et al. 2007. *Marine Biology* 152:449–460.
Schott, EJ et al. *Journal of Shellfish Research*, submitted.
Stoecker, DK et al. *Marine Biology*, in press.
Tamburri, MN et al. *Journal of Shellfish Research*, in press.
Wang, H et al. 2004. *Aquaculture* 242:137-155.
Wang, H and X Guo. *Journal of Shellfish Research*, in press.
Zhang, Q et al. 2005. *Biotechnology* 7:588-599.

Newsletter produced by:
Michelle O'Herron, IMSG/NOAA Chesapeake Bay Office
Jamie King, NOAA Chesapeake Bay Office
Caroline Wicks, EcoCheck (NOAA-UMCES Partnership)

Printed on post-consumer recycled paper
Printed: October 2007